Endodontic controversies
Structural & Technological Insights

by Clifford J. Ruddle, DDS

Since the beginning of endodontics, every decade has witnessed controversy. Currently, there is ongoing debate regarding the concept of minimally invasive endodontics (MIE) as it clinically relates to preparing any given access cavity or canal. Although the concept of MIE is noble, logical, and deserves discussion, it is appreciated that this concept is abstract, subjective, and is physically dimensionless. The paradox for a clinician practicing MIE is to find a balance between maximally conserving the structural integrity of any given tooth while at the same time completely eliminating the irritants from the root canal system ***(Figures 1-2)***.

For most, MIE is driven by a non-evidence-based fear that endodontic treatment predisposes to hopeless radicular fractures. For others, the interest in MIE is enabled by new technologies and techniques that maximize residual dentin. For a few, MIE is driven by the delusional notion that lesions of endodontic origin (LEOs) heal because treatment, even when incomplete, serves to reduce the microbial load and induce

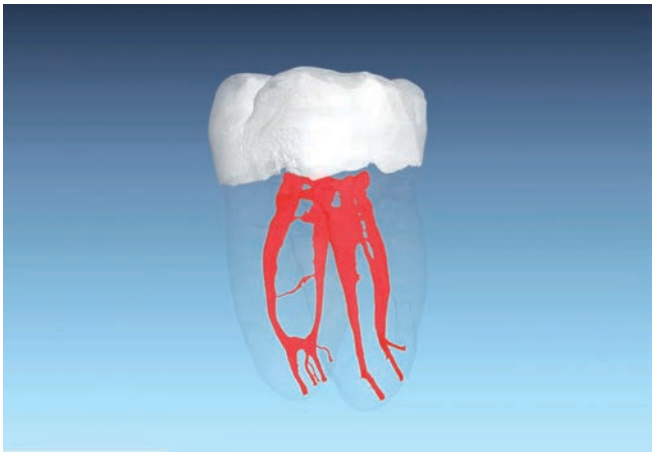

Figure 1. *A μCT image demonstrates root canal system anatomy and its implications when performing treatment. (Courtesy of Dr. Frank Paque; Zurich, Switzerland)*

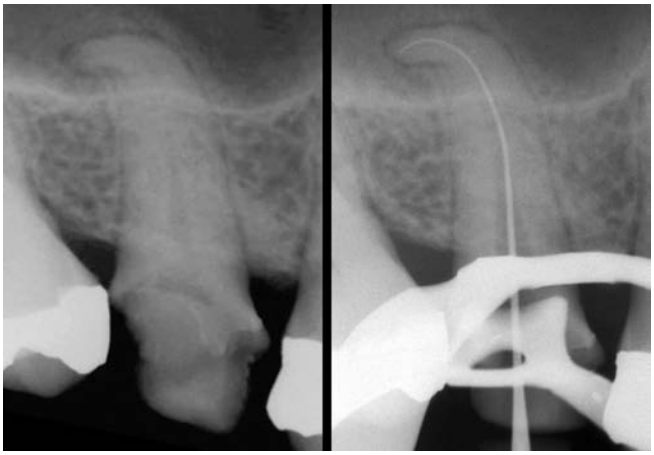

Figure 2a. *Left: A radiographic image of a maxillary bicuspid reveals a prepared crown, a receded pulp chamber, and a dilacerated root. Right: This working film demonstrates the strategy of pre-enlargement, which facilitates sliding a small-sized and pre-curved file to length.*

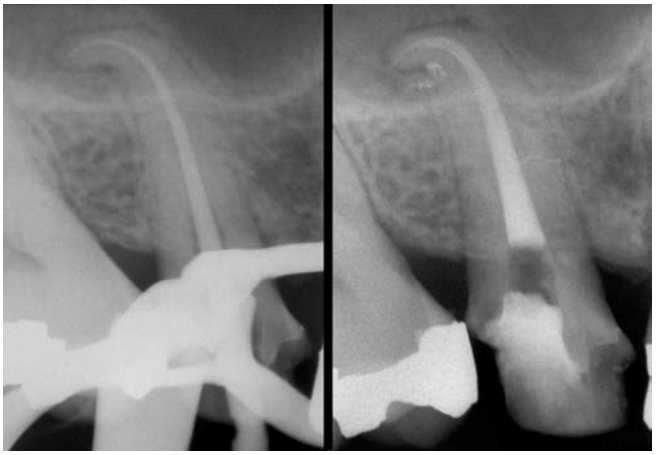

Figure 2b. *Left: This working film demonstrates a gutta percha master cone has slid around abrupt curvature and is at length. Right: The post-treatment film emphasizes that well-shaped canals promote 3D irrigation and filling root canal systems.*

bacterial dormancy. In today's world of treatment potential, it is astonishing that any endodontist would propose intentionally leaving irritants in a root canal system in order to save tooth structure, any more than operative or restorative dentists would propose leaving residual caries or defend cementing a crown with an open margin.

There are generally 2 clinical steps in conventional endodontics that remove tooth structure and, in turn, most serve to spark the conversation of MIE. This article will identify the structural considerations and related controversies when cutting access cavities and shaping canals. Finally, this article will identify endodontic misinformation in the marketplace, examine the credibility of a specific marketing campaign, and provide technological insight into certain controversial shaping files used for preparing canals. The purpose of this article is to ignite common sense, help dentists find their own truth, and examine how each decision serves to influence endodontic prognosis, costs, and chairtime.

Access Cavity Controversies

One controversy in clinical endodontics is the size of the access cavity. The trend to cut smaller-sized access cavities was first influenced by the utilization of the dental operating microscope and continues with the emergence of technologies such as CBCT, the optical surface scanner, and the 3D printed template.[1] However, from a teacher's perspective, virtually all dentists benefit from working through a more traditionally-sized access cavity ***(Figure 3)***. The structural considerations when cutting the access cavity are to maximize residual dentin, yet be able to readily identify each and every orifice. Ultimately, the size of the access preparation should facilitate shaping canals, 3D disinfection, and filling root canal systems ***(Figure 4)***.[2]

Recently, variously-sized access cavity designs have been described and compared, including the traditional endodontic cavity, the conservative endodontic cavity, and the so-called "ninja" endodontic cavity.[3] The controversy should not be whether to completely de-roof or partially de-roof a pulp chamber, or whether to cut a ninja-type access cavity to any given orifice; rather, the answer to this debate should be based on the reality of "do what you can, with what you got, where you are." Ultimately, the size of the access cavity is most influenced by anatomical knowledge, experience, and the technologies and methods utilized to shape, 3D clean, and fill root canal systems ***(Figure 5)***.

Traditionally-sized access cavities only reduce tooth stiffness by 5%, whereas cutting an MOD preparation decreases tooth stiffness by more than 60%.[4] Yet, it is appreciated that it is the cumulative loss of tooth structure that increases the possibility of radicular fracture. Tooth survival following endodontic treatment is most dependent on full coverage, as teeth without full coronal coverage are extracted 6 times more frequently ***(Figure 6)***.[5] In one large epidemiological study, initial endodontic treatment was performed by general dentists and endodontists in 1,462,936 teeth. Overall, 97% of these teeth were retained in the oral cavity for at least 8 years, while analysis of the 3% extracted teeth revealed that 85% had no full coronal coverage.[6]

Further, ongoing debate continues regarding whether to preserve, partially remove, or eliminate any given triangle of dentin. Yet, eliminating triangles of dentin allows the coronal aspect of any given canal to be intentionally relocated away from an external root concavity and toward the greatest bulk of dentin ***(Figure 7)***.[7] Histological evidence demonstrates that removing triangles of dentin results in more radicularly centered final preparations, which in turn, make teeth more fracture resistant.[8] Experienced dentists appreciate that, in the instance of full coronal coverage, the buccal and lingual aspects of a circumferential ferrule are far superior at resisting vertical and lateral occlusal loading as compared to the mesial and distal aspect of the same ferrule.[9]

Shape-Shifting Controversies

The mechanical necessity for shaping canals has long been recognized as an essential step in endodontic treatment. In 1974, Dr. Herb Schilder precisely described the mechanical objectives for preparing a canal that, when fulfilled, would ensure the biological goals for longterm success.[10] It is noteworthy that the Schilder concept of shaping canals is per-

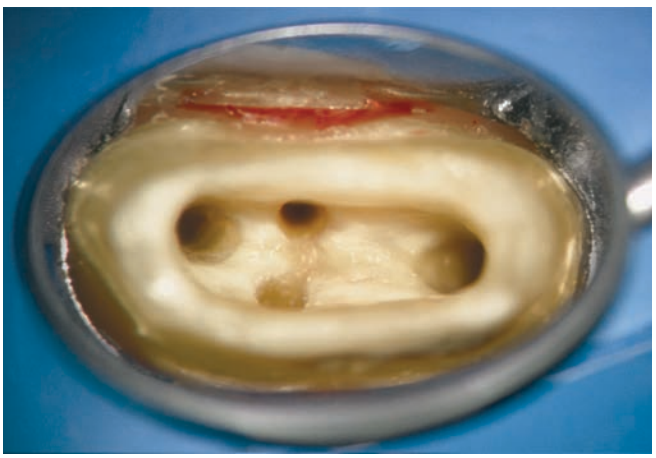

Figure 3. *A mouth mirror image demonstrates an access cavity and the outline pattern that just includes 4 orifices.*

Figure 4. *The endodontic triad is comprised of shaping canals, 3D disinfection, and filling root canal systems.*

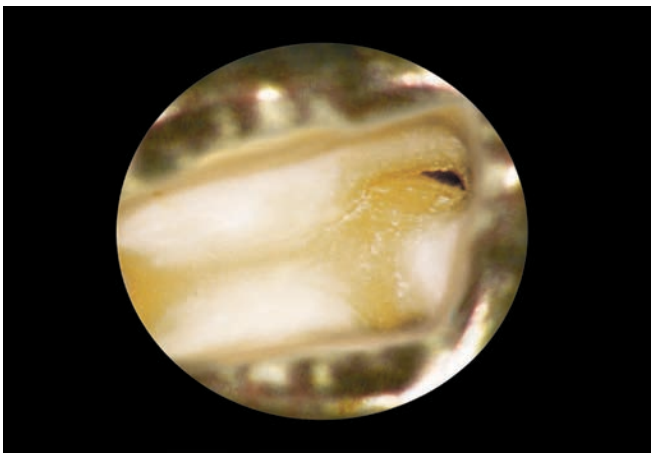

Figure 5a. *This microscope-captured image reveals the MB1 and related groove.*

Figure 5b. *This radiographic image demonstrates how shaping the MB canal facilitates active irrigation, 3D disinfection, and filling a complex root canal system.*

Figure 5c. *The post-treatment film illustrates complete 3D endodontics.*

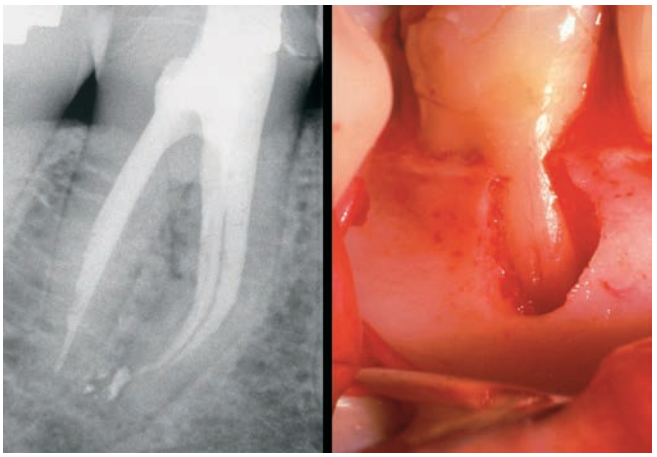

Figure 6. *Left: This failing mandibular molar was referred for evaluation. Note the ultra conservative access, overprepared canals, and lack of coronal coverage. Right: A surgical photograph of the same tooth confirms a vertical root fracture associated with the mesial root.*

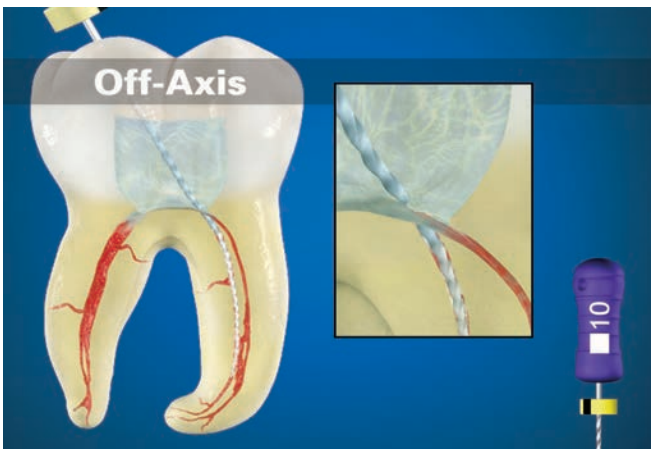

Figure 7a. *This molar and inset image both demonstrate that the handle of the size 10 file is off axis due to an internal shelf or triangle of dentin.*

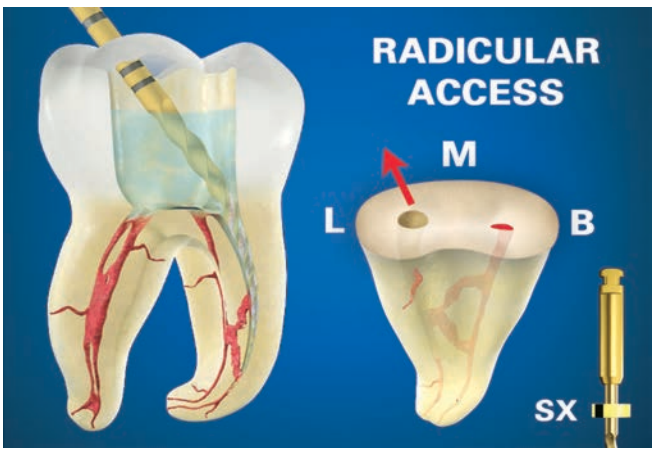

Figure 7b. *The left image shows the ProTaper SX file (Dentsply Sirona) brush-cutting away from furcal danger, resulting in a root-centered final preparation (inset).*

fectly consistent with the much more recent trend of MIE. However, while the Schilderian canal shaping objectives have undergone rigorous scientific and clinical scrutiny for over 40 years, MIE is an abstract shape-shifting concept, is subjective, and is physically dimensionless. The conundrum for proponents of MIE is that more minimally prepared canals are typically more minimally cleaned and rarely exhibit filled root canal systems.

The quintessential goal of preparing a canal is to create sufficient space to facilitate the exchange of irrigants into all aspects of the root canal system ***(Figures 4, 8)***.[11] Ideally, shaping is the conscious development of a preparation that mechanically reproduces, appropriately enlarges, and flows with the original anatomy ***(Figure 9)***. With that said, dentists can, at times, observe asymptomatic patients whose radiographic images exhibit deficiencies in primary endodontic treatment, yet an absence of pathology. However, this anecdotal sometimes success is offset by the fact that a few million endodontically treated teeth fail annually and require invasive retreatment, surgery, or extraction.[12]

The dimensions of the final shape will directly influence the technologies that can be used for 3D disinfection and filling root canal systems. In turn, these technologies should be supported by collaborative evidence, be easy to use, and be readily affordable. Histological evidence demonstrates that canals shaped to a size 25/08 can be effectively cleaned as well as their related root canal systems.[13] However, there is growing advocacy, largely without scientific evidence, to prepare any given canal to a minimal dimension of a size 15/04 file. Again, the debate is centered on whether these small-sized shapes and their related root canal systems can be effectively and affordably disinfected and predictably filled, or if necessary, reversibly retreated.

Shaping File Controversies

Beyond the extent of tooth structure removal is the controversy related to the deceptive marketing hype associated with specific shaping files. Certain companies make unsubstantiated claims that their files contact all of the internal walls of a canal, including irregular cross-sections. On the contrary, there is no biological or mechanical requirement for any shaping file to contact all the internal walls of a developing preparation, as it is the reagents and active irrigation technologies that actually serve to clean a root canal system.[11] Misinformation continues that a low working torque somehow equates to improved safety when, in fact, the optimal torque for any given file is dependent on its own design, metallurgy, and movement.[14]

In most instances, companies that "imitate" try to beat a competitor through cost, not through quality and performance. One relentless marketing campaign compares the resistance to cyclic fatigue among different file brands, then claims "Twice the cyclic fatigue, half the cost." In this specific ad, a particular file is reported to run for 677 seconds without breaking compared to 312 seconds for ProTaper Gold (PTG, *Dentsply Sirona*). This meaningless, high cyclic fatigue value is completely irrelevant. When a glide path has been secured, clinical experience confirms that virtually any given shaping file can be carried to the full working length in 1 or 2 or 3 passes, where each pass takes only about 5-7 seconds.

The resistance to cyclic fatigue should ideally be balanced with actual clinical performance, or the working torque required to safely and efficiently cut dentin. To achieve such a high cyclic fatigue value, any given file system has to go through an *excessive* heat treatment process. These "over-cooked" files' active blades prematurely dull, lose their cutting efficiency, and oftentimes prematurely unwind ***(Figure 10a)***. Certainly, it is preferable for a file to occasionally unwind vs. break; however, the marketing promise of "half the cost" is frequently offset by the cost incurred of needing another new same-sized file. Worse, are the additional stress and financial costs associated with a loss of cutting efficiency and the time expended needlessly changing files.

To assess the unwinding and suspected chairtime issues, I used S-block training models to compare the recommended 4-file sequence of a specific brand of over-cooked files

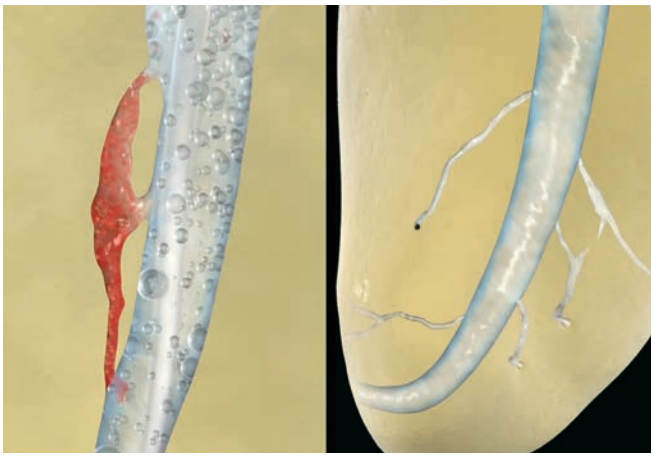

Figure 8. *The left image reveals the initiation of dynamic irrigation in a loop, whereas the right image shows the result of active 3D irrigation.*

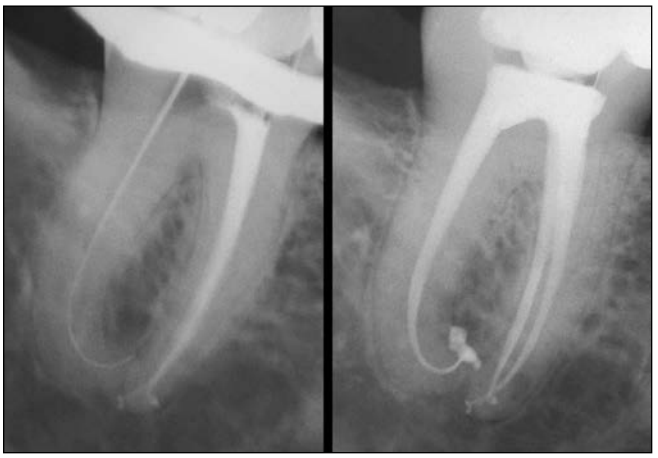

Figure 9. *The left image shows a size 10 file around the curvature and at length, whereas the right image demonstrates filled root canal systems.*

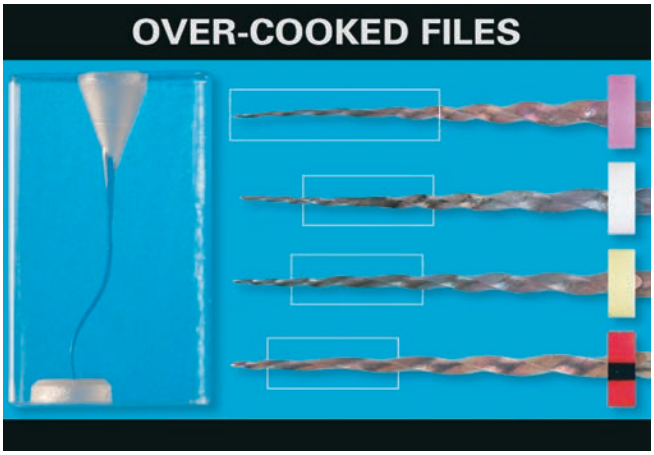

Figure 10a. *This image shows the result of using excessively heat-treated files. These "over-cooked" files prematurely unwound when shaping an S-block canal.*

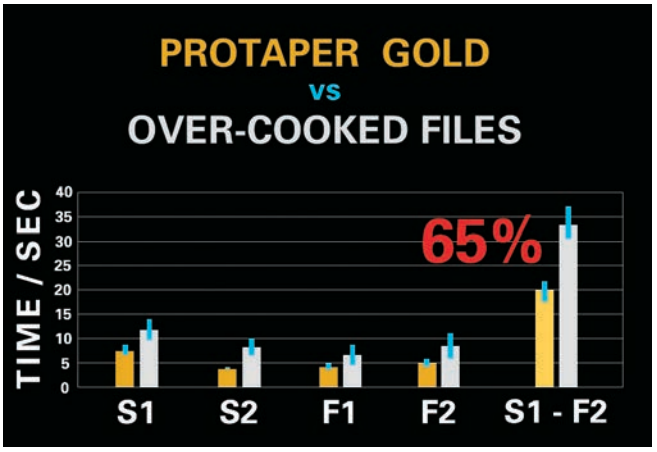

Figure 10b. *This graph shows that a ProTaper Gold (PTG) 4-file sequence requires 65% less shaping time to prepare a canal as compared to the over-cooked files.*

against the PTG 4-file sequence. I unwound at least one over-cooked file, and at times 2 files, in every single S-shaped canal prepared. For comparison, I was able to shape 10 S-blocks with PTG using the exact same files and 4-file sequence with zero unwinds! Beyond the bad news of premature unwinding, the worse news is the over-cooked 4-file sequence required about 65% more shaping time to prepare an S-curved canal as compared to the 4-file PTG sequence ***(Figure 10b)***. This experience can be readily duplicated by any dentist willing to invest 5 minutes of time.

To summarize, precise heat treatment provides an impressive resistance to cyclic fatigue and clinical advancement in safety and performance. However, the best file brands balance optimal heat treatment with clinical cutting efficiency. When a marketing campaign claims, "Twice as good, half the price," the question begs, does a file that dulls prematurely, frequently unwinds, and requires 65% more time to shape a canal, offer any value whatsoever? The goal here is to help dentists understand and appreciate that excessive heat treatment frequently contributes to unexpected costs and an undesirable clinical performance.

Future

The future of endodontics is not a debate over the size of the access cavity, or the dimensions of the final shape, or the ongoing distractions from marketing misinformation. Rather, the future will be most influenced by 3D disinfection and obturation technologies that can 3D clean and fill both minimally and fully prepared canals. New and affordable laser-activated irrigation technologies are on the horizon and are inspiring innovative methods to 3D fill minimally prepared canals and their related root canal systems. Bioactive materials, nanotechnology, and imagination will spark the field of regenerative endodontics, which in turn will invent a new obturation future. As Steve Jobs said, "The best way to predict the future is to invent it."▲

References:

1. Zehnder MS, Connert T, Weiger R, Krastl G, Kühl S: Guided endodontics: accuracy of a novel method for guided access cavity preparation and root canal location, *Int Endod J* 49:10, pp. 966-972, 2016.

2. Krishan R, Paqué F, Ossareh A, Kishen A, Dao T, Friedman S: Impacts of conservative endodontic cavity on root canal instrumentation efficacy and resistance to fracture assessed in incisors, premolars, and molars, *J Endod* 40:8, pp. 1160-1166, 2014.

3. Plotino G, Grande NM, Isufi A, Ioppolo P, Pedullà E, Bedini R, Gambarini G, Testarelli L: Fracture strength of endodontically treated teeth with different access cavity designs, *J Endod* 43:6, pp. 995-1000, 2017.

4. Reeh ES, Messer HH, Douglas WH: Reduction in tooth stiffness as a result of endodontic and restorative procedures, *J Endod* 15:11, pp. 512-516, 1989.

5. Aquilino SA, Caplan DJ: Relationship between crown placement and the survival of endodontically treated teeth, *J Prosthet Dent* 87:3, pp. 256-263, 2002.

6. Salehrabi R, Rotstein I: Endodontic treatment outcomes in a large patient population in the USA: an epidemiological study, *J Endod* 30:12, pp. 846-850, 2004.

7. Ruddle CJ: Locating canals: strategies, armamentarium, and techniques, *Dent Today* 36:2, pp. 122-125, 2017.

8. Ruddle CJ: The protaper technique, *Endodontic Topics* 10:187-190, 2005.

9. Sorensen JA, Engelman MJ: Ferrule design and fracture resistance of endodontically treated teeth, *J Prosthet Dent* 63:529, 1990.

10. Schilder H: Cleaning and shaping the root canal, *Dent Clin North Am* 18:2, pp. 269-296, April 1974.

11. Kanter V, Weldon E, Nair U, Varella C, Kanter K, Anusavice K, Pileggi R: A quantitative and qualitative analysis of ultrasonic versus sonic endodontic systems on canal cleanliness and obturation, *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 112:6, pp. 809-813, 2011.

12. Ruddle CJ: Ch. 25, Nonsurgical endodontic retreatment. In *Pathways of the Pulp*, 8th ed., Cohen S, Burns RC, eds., St. Louis: Mosby, pp. 875-929, 2002.

13. Albrecht LJ, Baumgartner JC, Marshall JG: Evaluation of apical debris removal using various sizes and tapers of profile GT files, *J Endod* 30:6, pp. 425-428, 2004.

14. Blum JY, Machtou P, Ruddle CJ, Micallef JP: Analysis of mechanical preparations in extracted teeth using ProTaper rotary instruments; value of the safety quotient, *J Endod* 29:9, pp. 567-575, 2003.